# New Water Technology Headed for Parched Places

## Capacitive deionization to debut in drought-struck Australia

NEXT MONTH an Australian-led coalition is expected to unveil a project to build experimental water-purification reactors in drought-plagued northeastern Australia. Parched cities in Queensland and New South Wales are turning to capacitive deionization (CDI), an electric field–based water desalination technology that could make inland water desalination much more affordable. CDI has long been stuck in laboratories and ignored by municipalities, which have preferred a mechanical method called reverse osmosis. But worsening inland droughts, massive private funding, and an international research effort are giving the alternative desalination technology its big break. CDI's backers say it will be on the market in 2009.

The dominant desalination technologies rely on membranes that frequently need replacement and cleaning. The most common, reverse osmosis, filters impurities by pushing pressurized water through a membrane. Another uses an electric field to drive the ions across a membrane.

CDI, in contrast, needs no membrane. In water, salts are dissolved as positively charged and negatively charged ions. CDI streams water between pairs of two oppositely charged porous electrodes. The negative ions drift into the pores of the positive electrodes and the positive ions drift to the negative, leaving pure, deionized water. Once the electrodes are "full," the reactor is stopped. The polarity of the electrodes is then reversed, and the ions are repelled. The ions are then flushed out of the reactor, flowing into a waste stream of supersalty brine.

Hoping to increase the electrodes' ion capacity and thus improve CDI's economics, Lawrence Livermore National Laboratory built the electrodes out of conductive carbon aerogel, a material with a surface area about 260 million times its volume (a grape-size piece has the surface area of two basketball courts). The aerogel's pores trapped huge

**SPARE SOME WATER, MATE?** Brisbane, Australia, and surrounding areas are experiencing a severe drought. The region plans to try a new desalination technology, capacitive deionization, to make its brackish water drinkable.
*PHOTO: JONATHAN WOOD/ GETTY IMAGES*

numbers of ions before they were saturated, but they were also prone to clogging up with bacteria, which feed on organic particles in the water.

Bob Campbell, CEO of California-based Campbell Applied Physics, which is managing the Australia project, tackled the problem. With funding from Malta-based Water Resources International, Campbell worked with four U.S. Department of Energy national laboratories, among them Lawrence Livermore. The team developed a proprietary ozone technology that kills the bacteria before they can fill the aerogel's pores, says Lawrence Livermore technologist Bill Daily, who is developing the deionization reactors for the Australia project.

Northeastern Australia will be the first to commercialize CDI because of the proximity of parched cities to coal-bed gas mines, where pressurized underground water is used to release the trapped gas. The by-product is water that, though ample, is too brackish even for most agricultural uses. Many in the water industry have predicted that Australian demand for water-purification technology will spike as the mining industry taps the deep coal deposits in Australia's largest aquifer.

The reason reverse osmosis has dominated the market, and hence discouraged research into other methods, is that municipalities wanting water desalination have usually been coastal: huge desalination plants are built on shorelines in the Middle East, China, California, and Texas.

**SOLID SMOKE:** Superporous carbon aerogels are CDI's secret.

PHOTO: JPL/NASA

Where the water's salt content is high—it's about 32 000 milligrams per liter in ocean water—reverse osmosis is efficient and cost-effective. But for inland brackish waters, in which there might be 800 to 3500 mg/L of salt, CDI requires less energy, says Frost & Sullivan analyst Afamia Elnakat.

Until recently, opportunities for inland desalination were scarce because, as Elnakat says, "the water problem just hasn't hit anyone in the pocket yet." But inland droughts are starting to become ruinous. In the past two years, water levels in northeastern Australia have dropped to one quarter of their normal depth, causing barley and wheat production to plummet (and contributing to the country's decision to sign onto the Kyoto climate agreement). Similar long-term droughts have laid waste to water supplies in China and in the southwestern United States.

In these situations, CDI is a clear winner, argues Campbell. Its main efficiency advantage versus reverse osmosis is that it doesn't need pressurized water. CDI can also save power by allowing for "dial-in" ion concentrations: for medically pure water, for example, the reactors can remove all dissolved ions; but for agriculture the water can be somewhat saltier. The fewer ions that need to be removed, the longer the reactors can go between rinses.

And deionization might play a role in seawater desalination too. The World Health Organization warns that the natural boron content in seawater has been linked to developmental and reproductive disorders. Boron ions can slip through reverse osmosis systems. Campbell says that CDI can be a postosmosis "polishing" step to filter the boron.

—Sarah Adee

JEFF TOPPING/THE NEW YORK TIMES/REDUX

## WHAT ARE THE CHANCES?

Martin Hellman, professor emeritus at Stanford, used engineering risk analysis methods to determine the failure rate for the United States' nuclear deterrence strategy and came up with a shocking 1 percent chance per year that a nuclear war will break out.

*More at http://www.spectrum.ieee.org/apr08/deterrence*